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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003905717 for a patent by ACTIVE AIR SUSPENSIONS LIMITED as filed on 17 October 2003.

WITNESS my hand this
Second day of November 2004

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ORIGINAL

AUSTRALIA

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PROVISIONAL SPECIFICATION

Invention Title: "Vehicle Suspension Control"

The invention is described in the following statement:

"Vehicle Suspension Control"

Field of the Invention

This invention relates to a vehicle suspension control which is intended to control the suspension system of vehicle.

Background Art

Conventional vehicle suspension systems are generally passive and usually comprise metallic coil springs supplemented by hydraulic shock absorbers that provide a damping function. The suspension systems are generally used to smooth out vehicle ride action over rough or uneven terrain. In general the vehicle follows the contours of the road and as a result the attitude or departure of the vehicle chassis from the horizontal is a function of the locations of the four wheels supporting the chassis. Therefore if a wheel drops into a pot hole or rides up on a high point then the vehicle will tend to follow the same path. The performance of the conventional style of suspension can be optimised for either the road (smooth terrain) or off-road (uneven terrain) but not both. Off road the vehicle performance is generally compromised and safe effective speeds are constrained because of the nature of the suspension system.

Disclosure of the Invention

The present invention is directed to an active suspension system which utilises sensors associated with the vehicle and a controller which reacts to the sensor value and provides signals to suspension units of the vehicle in order to provide positive control over chassis dynamics.

Throughout the specification the term fluid shall be take to include compressible fluids such as gaseous fluids.

Accordingly the invention resides in a vehicle suspension control for a vehicle in which each wheel is supported from the chassis of the vehicle through a fluid

operated extension element which can control a degree of relative displacement between the wheel and the chassis, the extension element enabling the resilient relative movement between the vehicle and chassis said control comprising:

a controller;

a plurality of sensors associated with each wheel of the vehicle;

a fluid flow controller comprising a fluid flow delivery means and a fluid exhaust means associated with each extension element;

a first sensor adapted to sense the relative position between the wheel and the chassis and provide a first output tot the controller;

a second sensor adapted to sense the pressure of the fluid in each extension element and provide a second output to the controller;

the controller adapted to receive the output from each of the sensors at each wheel, process the outputs and provide a wheel output to the fluid flow controller for each wheel to control the delivery of fluid or the exhaustion of fluid from respective extension element whereby the fluid pressure within each extension element is varied in order that the force applied by the extension elements between the chassis and wheels will maintain the attitude of the chassis to a plane substantially constant.

According to a preferred feature of the invention the plane comprises the general plane of the ground being traversed.

According to a preferred feature of the invention the wheel output for each wheel comprises a signal derived from the first output of each of the sensors of the respective wheel together with the first output from the sensors of adjacent wheels. According to one embodiment the adjacent wheels comprise a wheel which is most adjacent along the transverse axis of the chassis and a wheel which is most adjacent along a longitudinal axis of the chassis.

According to a preferred feature of the invention the controller comprises a third sensor provided on the chassis and adapted to provide a third output which is representative of the movement of the chassis in the vertical sense over the ground relative to free space. According to a preferred feature of the invention the controller comprises a fourth sensor adapted to provide a fourth output representative of the lateral acceleration of the chassis. According to a preferred feature of the invention the controller comprises a fifth sensor adapted to provide a fifth output representative of the steering angle of the steering wheels. According to a preferred feature of the invention the controller comprises a sixth sensor adapted to provide a sixth output representative of the speed of the chassis over the ground.

According to a preferred feature of the invention the wheel output signal for a wheel comprises a summation of the first output from the first sensor of the respective wheel, the first output from the first sensor of each of the adjacent wheels, the second output from the second sensor of the respective wheel. According to a preferred feature of the invention the weighting applied to the first output of the respective wheel and the first output of each of the adjacent wheels is of the order of 2:1. According to a further preferred feature of the invention the controller includes an adjustable control connected to the controller which provides a control signal which can be adjusted to vary the weighting or bias applied to the first outputs from each of the first sensors in determining the wheel output to control the permitted degree of change in attitude of the chassis relative to the plane. According to a preferred embodiment of the invention the summation of the first signals is biased by the control signal before the second signal is included to produce a resultant signal. According to a preferred feature of the invention the weighting applied between the resultant signal and the second signal is of the order of 10:1 in deriving the wheel output.

According to a preferred feature of the invention the adjustable control provides a control signal comprising a pitch control, a roll control and a height control component. According to a preferred feature of the invention the control signal comprises a first control signal which is set to control the height of the chassis

relative to the wheels. According to a preferred feature of the invention the control signal comprises a second control signal which is set to control the permitted degree of roll of the chassis relative to the plane. According to a preferred feature of the invention the control signal comprises a third control signal which is set to control the permitted degree of pitch variation of the chassis relative to the plane.

According to a preferred feature of the invention the controller can include a gyroscopic device adapted to provide a signal indicative of the horizontal plane. According to a preferred feature of the invention the plane can be varied in its inclination

According to a further aspect of the invention the invention resides in a damping control for a vehicle comprising a fluid operated damper between each wheel and the chassis each damper being capable of providing a variable degree of damping, each damper being controlled by a damper control, the control comprising the set of first sensors which provide a first output indicative of the relative position between the wheels and the chassis and a set of third sensors adapted to provide a third output indicative of the relative motion between the wheels and the chassis, the control further comprising a second control which receives the signal from the first and third sensors for each wheel, said second control providing a damping output to the damper control of each damper to vary the degree of damping applied by the damper in proportion to the third output wherein the signal from the third sensor is allowed or inhibited by the relative motion output of the first sensors.

The effect of the damper control is such that if wheels are moving toward the chassis and the chassis is experiencing upwards acceleration then no signal is provided to the damper, however if the wheels are moving away from the chassis and the chassis is experiencing upwards acceleration then the signal to the damper is enabled. In the event that the wheels are moving toward the chassis and the chassis is experiencing downwards acceleration then the signal to the damper is enabled, however if the wheels are moving away from the

chassis and the chassis is experiencing downwards acceleration then no signal is provided to the damper. .

According to a preferred embodiment of the invention the chassis will maintain a constant attitude relative to the general ground plane.

According to a preferred embodiment of the invention the chassis will maintain a constant attitude relative to the horizontal.

According to a preferred feature of the invention the invention comprises a vehicle suspension control of the form described above together with a damper control of the form described above where the first sensor and the first output and the third sensor and the third output of the vehicle suspension control comprise the first sensor and the first output and the third sensor and the third output of the damper control.

According to a further aspect of the present invention there is provided a suspension system for a vehicle comprising a chassis and at least front and rear axles supporting wheels for rotational movement wherein said suspension system comprises resilient support members to provide resilient support for each of said wheels from said chassis which said resilient support members are controllable by a controller to vary relative displacement between each said wheel and said chassis and wherein said controller receives control signals from sensors operatively associated with said suspension system to provide signals indicative of relative displacement between each said wheel and said chassis and wherein in response to said signals said controller provides a control signal to each said resilient support member to thereby control said relative displacement between each said wheel and said chassis so as to maintain the attitude of said chassis substantially parallel with a plane of average axle articulation wherein said plane of average axle articulation comprises a plane bisecting an included angle formed between first and second planes wherein said first plane is a plane passing through said front axle of said vehicle and said second plane is a plane passing through said rear axle of said vehicle.

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